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**ULTRA-LOW FREQUENCY
REJECTION FILTER**



**OPERATING AND MAINTENANCE
MANUAL**

Model 350-A

SERIAL NO. 352

KROHN-HITE CORPORATION

580 Massachusetts Ave., Cambridge 39, Mass., U.S.A.

M O D E L 3 5 0 - A

THE FOLLOWING CHANGES, ADDITIONS, AND CORRECTIONS ARE NOT REFLECTED IN THE INSTRUCTION MANUAL AND MAY BE ADDED AT THE DISCRETION OF THE CUSTOMER.

Under "POWER AND FUSE REQUIREMENTS":

Beginning with serial number 356, this model incorporated a dual primary power transformer as standard equipment giving the customer the option of 115V-1A/230V-.5A operation.

Under "TERMINALS":

Beginning with serial number 356, this model added a rear input and a rear output connector (BNC type) as standard equipment.

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for

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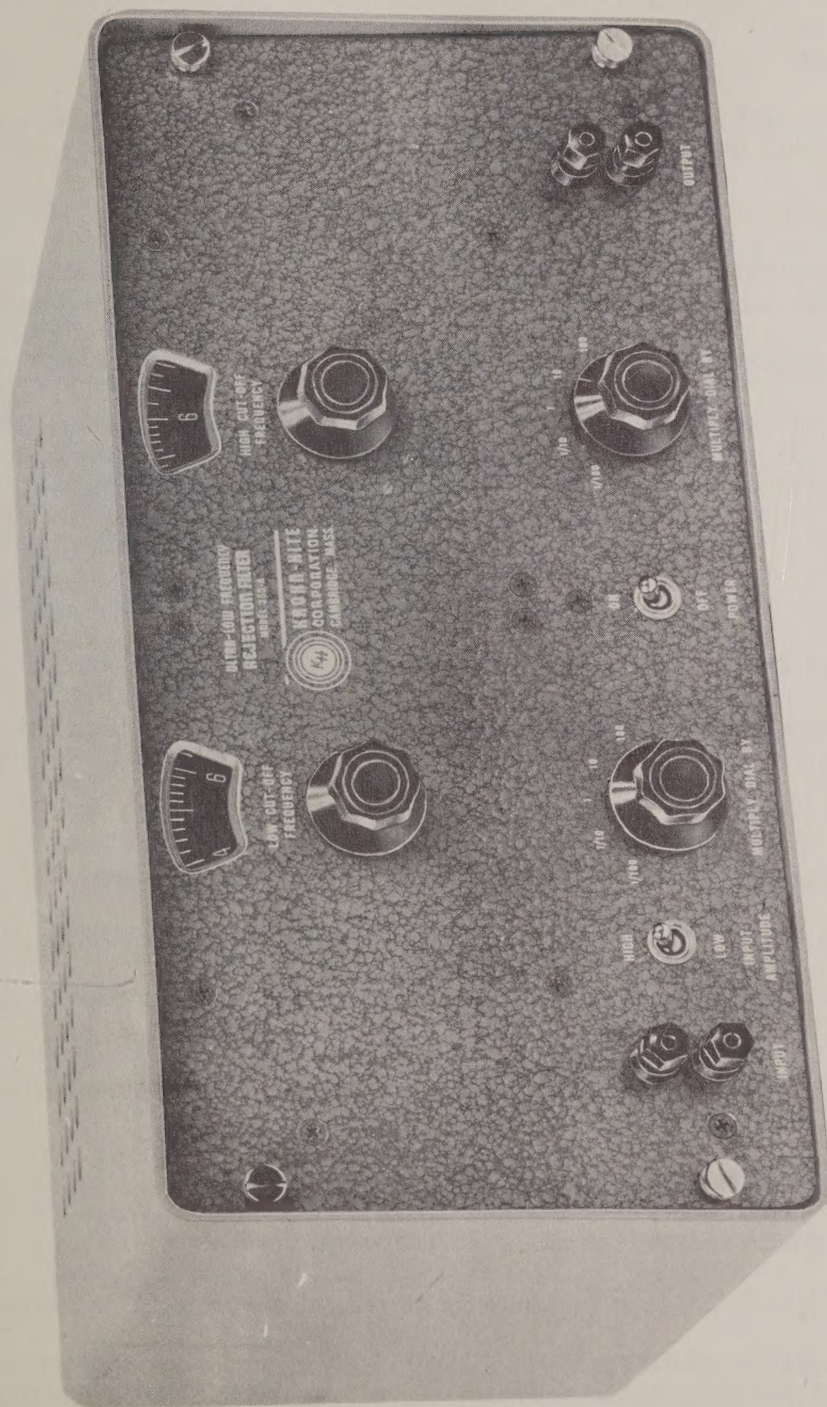


Figure 1 - MODEL 350-A ULTRA-LOW FREQUENCY REJECTION FILTER

SECTION I - GENERAL DESCRIPTION

1. TECHNICAL SUMMARY

TYPE: Band Rejection.

BAND WIDTH:

Sharp null, or continuously variable up to the maximum width covering entire frequency range from 0.02 cps to 2 kc.

FREQUENCY RANGE:

REJECTION BAND: High and low cut-off frequencies independently tuned; continuous from 0.02 cps to 2 kc in five decade bands.

<u>BAND</u>	<u>MULTIPLIER</u>	<u>FREQUENCY (CPS)</u>
1	1/100	0.02 - 0.20
2	1/10	0.20 - 2.0
3	1	2.0 - 20
4	10	20 - 200
5	100	200 - 2,000

NULL: Continuous from 0.1 to 500 cps.

FREQUENCY DIALS:

Single scale, illuminated, direct reading, engraved logarithmically from 1.9 to 21.

ACCURACY OF CUT-OFF: $\pm 5\%$

INSERTION LOSS:

Zero db ± 1 db for frequencies outside the rejection region with half power points at 0.01 cps and at 20 kc.

ATTENUATION SLOPE:

24 db per octave with peaking factor to reduce attenuation at the cut-off frequencies.

MAXIMUM ATTENUATION: Greater than 80 db.

INPUT CHARACTERISTICS:

IMPEDANCE: Approximately 20 megohms in parallel with 20 uuf.

MAXIMUM INPUT AMPLITUDE: 10 volts rms with INPUT AMPLITUDE switch in HIGH position. 1 volt rms with INPUT AMPLITUDE switch in LOW position.

MAXIMUM DC COMPONENT: 400 volts.

SECTION I - GENERAL DESCRIPTION

OUTPUT CHARACTERISTICS:

IMPEDANCE: 5,000 ohms with INPUT AMPLITUDE switch in HIGH position 500 ohms with INPUT AMPLITUDE switch in LOW position.

MAXIMUM POWER: 5 volts rms across 5,000 ohms or 5 milliwatts in HIGH position of INPUT AMPLITUDE switch.

INTERNALLY GENERATED HUM AND NOISE: Less than 1 millivolt with INPUT AMPLITUDE switch in HIGH position. Less than 100 microvolts with INPUT AMPLITUDE switch in LOW position.

CONTROLS:

LOW CUT-OFF FREQUENCY dial.
Low cut-off frequency MULTIPLY DIAL BY switch.
HIGH CUT-OFF FREQUENCY dial.
High cut-off frequency MULTIPLY DIAL BY switch.
INPUT AMPLITUDE HIGH-LOW switch.
POWER OFF-ON switch.

TERMINALS:

Two multi-purpose binding posts for the INPUT and two for the OUTPUT.

POWER REQUIREMENTS:

105-125 volts, single phase.
50-60 cycles
70 watts.

FUSE PROTECTION: 1 ampere slow-blow.

TUBE COMPLEMENT (furnished with instrument):

8-12AX7, 3-12AU7, 1-12AY7, 1-6AU5-GT, 1-6AX5-GT, 1-OG3/85A2.

FORM:

Overall dimensions Model 350-A: 17" wide, 8" high, 12" deep.
Weight 37 lbs. net, 42 lbs. shipping. Rack mounting available;
overall dimensions Model 350-AR: 19" wide, 8 3/4" high, 12" deep. Weight 37 lbs. net, 41 lbs. shipping.

SECTION I - GENERAL DESCRIPTION

2. DESCRIPTION

The Model 350-A adjustable Ultra-Low Frequency Rejection Filter provides either a sharp single frequency null (solid curve of Figure 2) or a rejection band in which the gain falls at a rate of 24 db/octave (solid curve of Figure 3). In either case the gain, outside the rejection region, is unity for all frequencies between 0.01 cps and 20 kc.

Both high and low cut-off frequencies are independently adjustable from 0.02 cps to 2 kc. This provides maximum flexibility of adjustment of both the band center frequency and the band width. A sharp null filter at any frequency between 0.1 and 500 cps is obtained by setting the high and low cut-off frequencies a factor of approximately 2 from the desired null frequency. The response is illustrated by the solid curve of Figure 2. The dotted curve presents for comparison the response of a balanced parallel "T" null filter.

Two identical frequency dials and multiplier switches are used for the two cut-off frequencies. Each dial is single scale, illuminated, direct reading, and engraved logarithmically from 1.9 to 21. The associated multiplier switch selects one of the five decade bands.

The transfer function of the filter is approximately:

$$\frac{1}{(1 + 2jA\omega T_1 - \omega^2 T_1^2)^2} + \frac{\omega^4 T_2^4}{(1 + 2jA\omega T_2 - \omega^2 T_2^2)^2}$$

where the low cut-off frequency is $1/2\pi T_1$ and the high cut-off frequency is $1/2\pi T_2$. The value of the peaking factor, "A", which is normally unity for filters composed of independent resistance-capacitance sections, is fixed in the Model 350-A at slightly greater than 0.6. This value produces less than 1 db peaks in the gain vs. frequency plot, but reduces the attenuation at the corner frequencies by approximately 9 db.

For most applications, the performance of the Model 350-A is better than that of a 24 db filter with unity peaking factor because, with the same attenuation in the rejection band, the gain near the corner frequencies is greater. Figure 3 shows gain vs. frequency for the 350-A (solid curve) and for a similar filter with $A = 1$ (dotted curve). The low cut-off is at 1 cps and the high cut-off at 100 cps.

Figure 4 shows the essential units of the filter in block diagram form. The Schematic is shown in Figure 7.

The filter section consists of parallel paths through a high-pass filter and a low-pass filter. Each is tuned continuously by a four-gang potentiometer assembly and in decade steps by a multiplier switch which changes the size of the filter condensers.

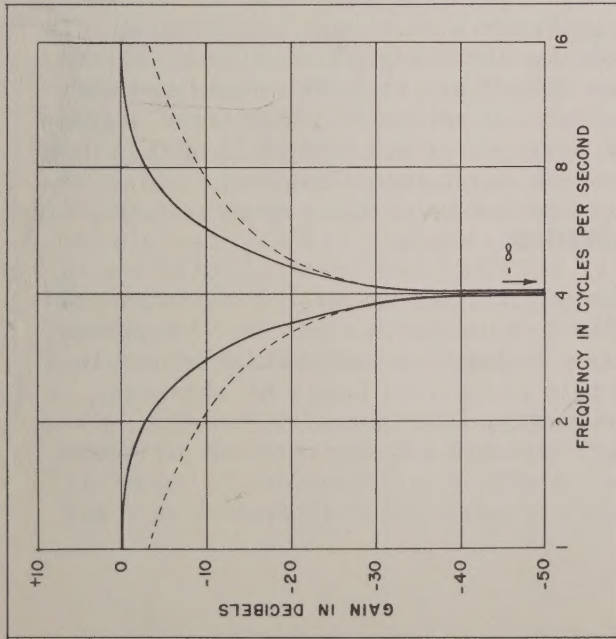


Figure 2 - Solid curve shows the null filter response of the Model 350-A. Dotted curve is the null response of a balanced parallel "T".

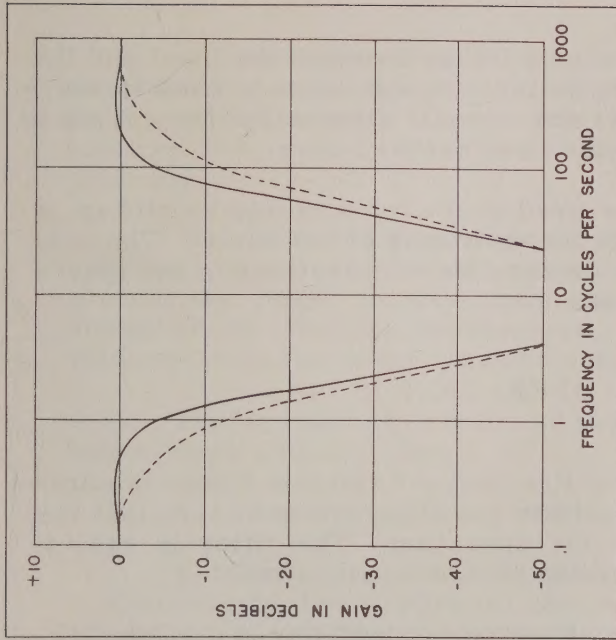


Figure 3 - Solid curve shows the band rejection response of the Model 350-A. Dotted curve is the response of a similar filter with no corner peaking.

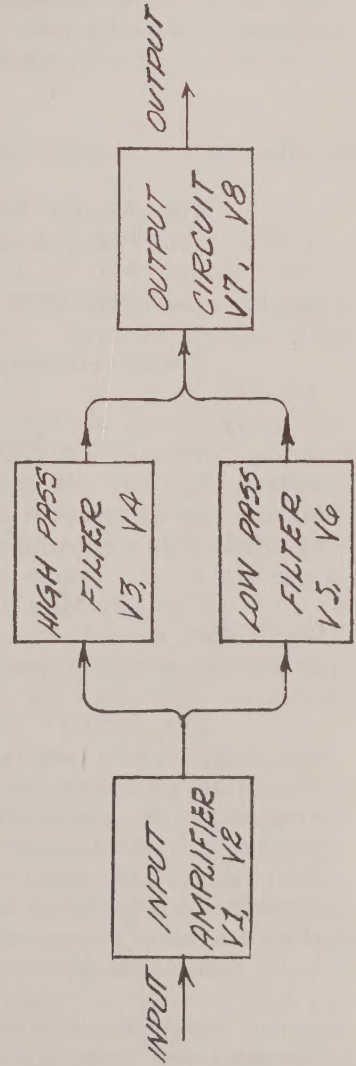


Figure 4 - Model 350-A Block Diagram

SECTION I - GENERAL DESCRIPTION

The input amplifier serves as a buffer between the input and the first stage of each of the filters. Sufficient amplification is used to overcome the loss in the filters so that the overall attenuation from input to output is approximately zero db in the pass band.

Since condenser coupling is used at the input to this amplifier, a dc signal component will not disturb the operation of the filter. The output circuit is used as a buffer to isolate the last sections of the filters and to provide a low output impedance.

SECTION II - OPERATION

The Model 350-A Ultra-Low Frequency Rejection Filter is completely checked and then carefully packed for shipment to ensure that the instrument will be received ready for operation. The filter is easy to operate and requires no initial warm up period or adjustment.

There are only five front panel controls in addition to the ON-OFF switch.

The HIGH CUT-OFF and LOW CUT-OFF FREQUENCY controls select the cut-off frequencies as read on single scale illuminated dials which are engraved logarithmically from 1.9 to 21 and calibrated directly in cycles per second.

The two MULTIPLY DIAL BY switches select the proper multiplying factor for all the five band, each of which covers a frequency range of 10 to 1 with 5% overlap.

The INPUT AMPLITUDE switch permits selection of filter characteristics which are most suitable for a particular application. In the HIGH position the filter will handle an input signal of at least 10 volts rms without overloading. The output impedance is 5,000 ohms and noise generated within the filter is less than one millivolt. For input signals less than one volt rms, the LOW position of the INPUT AMPLITUDE switch may be used to obtain 500 ohms output impedance and noise reduction by a factor of 10. Gain outside the rejection region is unity for both positions of the INPUT AMPLITUDE switch.

Sharp null filtering is obtained by setting the high and low cut-off frequencies a factor of approximately 2 from the desired null frequency. By successive readjustment of the two tuning controls, while monitoring the output of the filter, a more nearly perfect null may be obtained. A perfect null is realized when the two parts of the transfer function, given in the description, are equal in amplitude and 180 degrees out of phase.

SECTION III - MAINTENANCE

All the components in the Model 350-A are of the highest quality and should have a long trouble-free life since they are operated well below their manufacturers' rating. The following procedure may facilitate locating the source of trouble if the Rejection Filter does not function properly.

A 1-ampere slow-blow cartridge fuse, located in the back of the chassis, is used in the primary circuit of the power transformer to protect the power supply components from short circuits and this fuse should be selected for proper protection of the instrument and should be replaced with the same type and rating.

If a fuse failure is detected, the following procedure is recommended before replacing the fuse:

- a. Check for a faulty rectifier tube, 6AX5-GT.
- b. Short circuits in the 4 uf filter condensers, C54 and C55, used in the unregulated portion of the power supply, can best be detected by connecting an ohmmeter across the terminals directly.
- c. Two electronically regulated power supplies are used in the Model 350-A to provide plus 185 volts and minus 185 volts with respect to the chassis or ground. One convenient test point for the +185 volts is the cathode of the 6AU5-GT (pin #3). A convenient test point for the -185 volts is the negative side of the 4 uf filter condensers, C54 and C55. If a short to ground exists on either regulated voltage buss, check all the tie points connected to it.
- d. The dc resistance of the power transformer primary should be 4.5 ohms. A much lower resistance probably indicates a shorted primary.

The likeliest source of failure is the electron tubes since they have an inherently shorter life. Check first to see if all the tubes are inserted securely in the sockets. Although each tube is securely seated at the Plant, it is possible for them to be loosened in shipment. At the same time note if each tube's filament is lit and the voltage reference tube, OG3/85A2, is functioning properly as indicated by an amber glow in the tube. If the unit then fails to operate properly and the correct plate and heater supply voltages are present, check the possibility of a faulty tube. Obtain a new 12AU7, 12AX7 and 12AY7 (a 12AX7 may be substituted for a 12AY7 for this test) and then, one at a time, substitute the new tube in each position in the filter where it is used. The location of each electron tube is clearly marked on the chassis adjacent to the tube.

In most cases one of these substitutions will effect a cure. If, however, this approach does not help, a more detailed test must be made. Location of components to check can be facilitated by reference to the Top and Bottom View of Chassis, Figures 5 and 6 respectively. In addition,

SECTION III - MAINTENANCE

Figure 8, Table of Voltage and Resistance Measurements shows the correct operating voltage on every pin of each tube. Any appreciable discrepancy between the existing voltage as measured and the correct one, as shown in Figure 8, should be fully investigated.

SECTION IV - SERVICE AND WARRANTY

KROHN-HITE Instruments are designed and manufactured in accordance with sound engineering practices and should give long trouble-free service under normal operating conditions. If this Filter fails to provide satisfactory service and the source of trouble cannot be located, write to the Factory Service Department giving all the information available concerning the failure.

Do not return the Instrument without written authorization for, in most cases the information necessary to repair the Instrument can be provided, thus avoiding the transportation problems and costs. When it becomes necessary to return the Instrument to the Factory, kindly pack it carefully and ship via Express, prepaid.

KROHN-HITE Instruments are conservatively designed to provide continuous reliable service under normal laboratory conditions. The material and workmanship in every new instrument manufactured by KROHN-HITE is guaranteed for one year from the date of shipment to the original purchaser. Any instrument developing defects during this period will be repaired or replaced without charge when the failure is the result of defective material or workmanship. This warranty does not apply to electron tubes, fuses, batteries, transistors and other semiconductor devices.

KROHN-HITE reserves the right to make design changes at any time without incurring any obligation to incorporate these changes in instruments previously purchased.

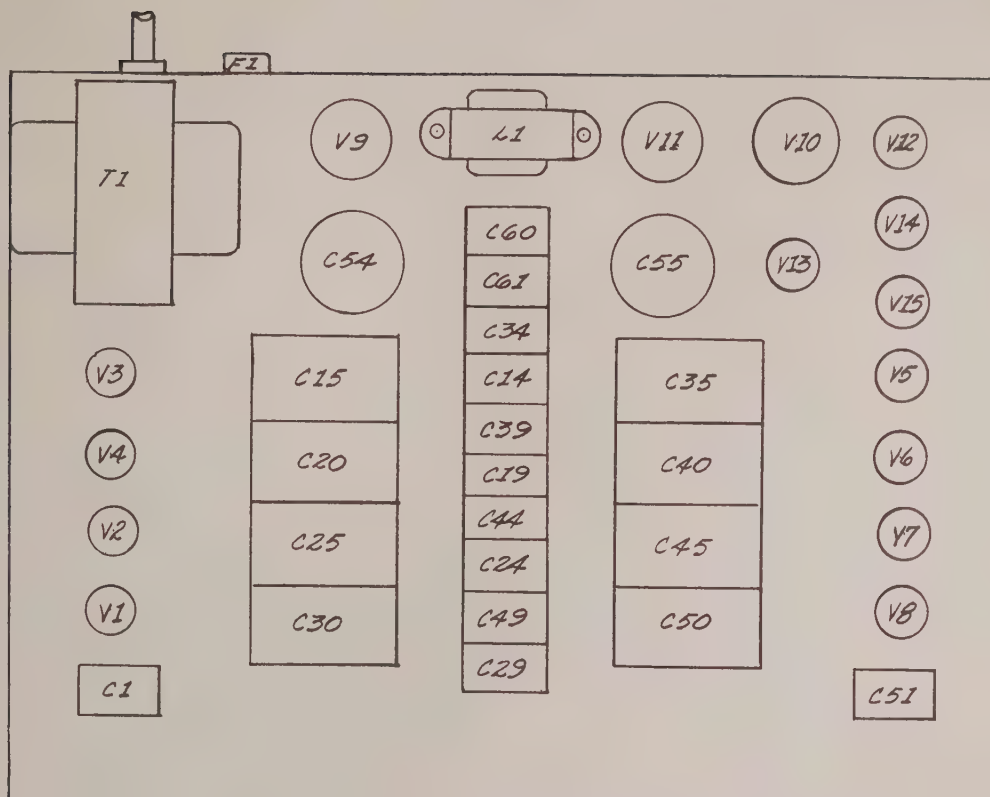


Figure 5 - Top View of Chassis

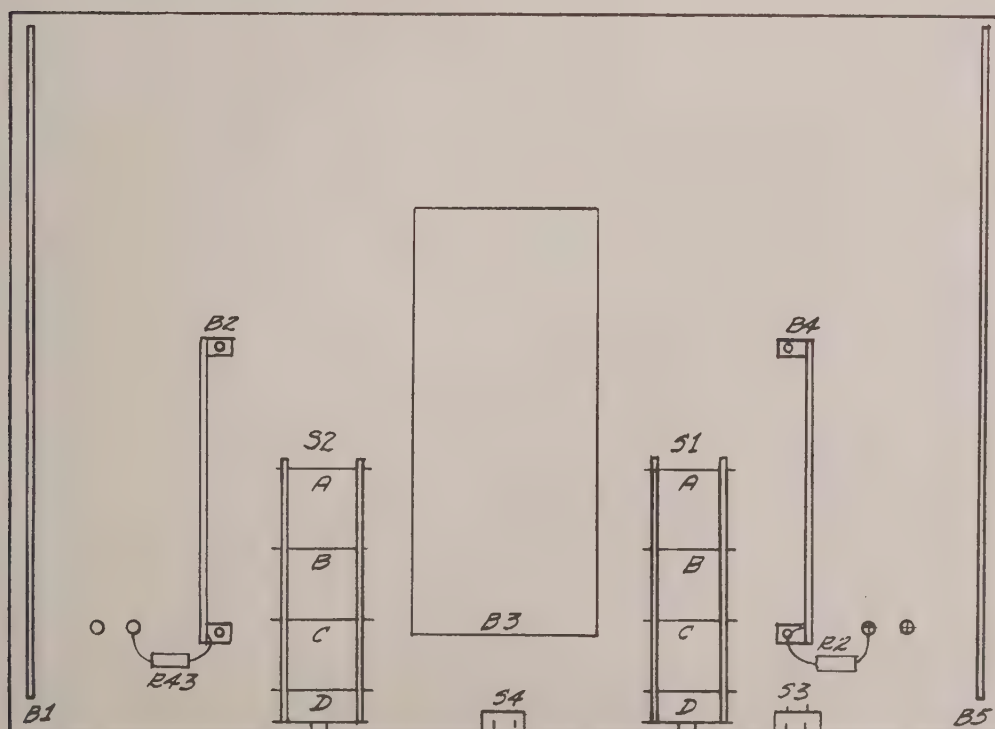


Figure 6 - Bottom View of Chassis

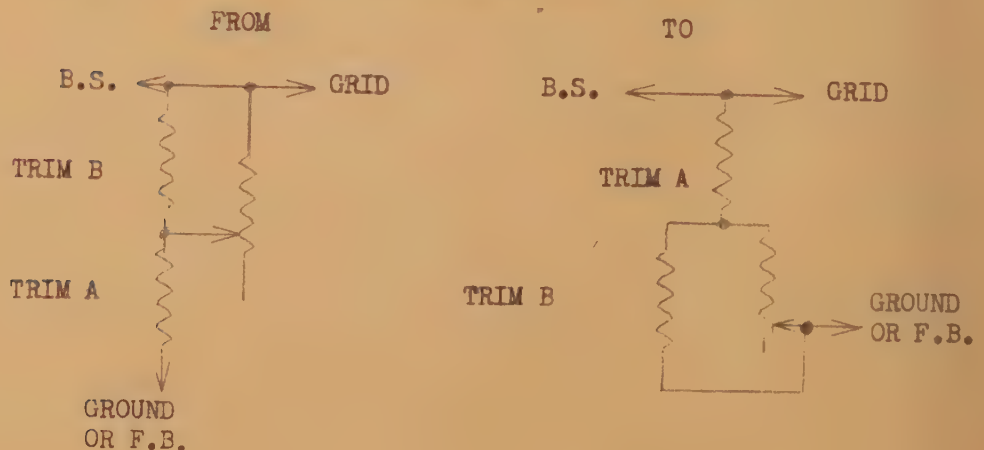
MODEL 350 - A

THE FOLLOWING CHANGES, ADDITIONS, & CORRECTIONS ARE NOT REFLECTED ON THE SCHEMATIC (REV. DATE: 11/13/59) AND MAY BE ADDED AT THE DISCRETION OF THE CUSTOMER.

STARTING WITH
SERIAL NO.

CHANGES, ADDITIONS, & CORRECTIONS

- 310 Add R85 (470 ohms 10% 1/2W) in series with pin 7 of V8.
- 333 (& inc. 268 & 328) CHANGES:
1) R10 (470 ohms 20% 1/2W) to 330 ohms 20% 1/2W.
2) R11 (1.5K 20% 1/2W) to 220 ohms 20% 1/2W.
3) C7 (.002 uf 20% 400V) to .0033 uf 20% 400V.
- 356 This model has added a dual primary power transformer as standard equipment.
For 115V-1A: jumper lugs 1&2 and jumper lugs # 3&4.
For 230V-1/2A: jumper lugs 2&3.
- CORRECTION: the junction of C3, R7A, & R7B should be removed from the ground buss and connected at the junction of R33A, R20, & R21.
- CORRECTIONS: 1) R62 should read 560K
2) C10 should read .001 uf.
- 356 Add a rear input and a rear output connector (BNC type).
- 357 Change the wiring of P1 (TUNING ASSEMBLY POTS.).



All voltage and resistance values measured from the pins of each socket to ground (chassis) with the controls in the following positions:

INPUT AMPLITUDE switch HIGH.

LOW CUT-OFF and HIGH CUT-OFF FREQUENCY dials at 20.

Both MULTIPLY DIAL BY switches at 100.

Voltages measured with instrument operating from 115 volt 60 cps source. DC voltages measured with a VTVM having an input resistance of 11 megohms.

Resistances measured with the power plug removed from the source.

TUBE		PIN NUMBER									
No.	Type		1	2	3	4	5	6	7	8	9
V1	12AY7	V	+100	0	+2.3±.5	W	W	115	0±1	+2.3±.5	W
		R	700K	22M	600K	100	100	500K	1.2M	600K	100
V2	12AX7	V	+125	-1±.5	0	Y	Y	-10	-130	-130	Y
		R	420K	1.2M	0	200	200	1.6M	700K	30K	200
V3	12AU7	V	+170	-3.5	5	Y	Y	+170	-10	-1.2	Y
		R	340K	200K	120K	200	200	340K	1.6M	600K	200
V4	12AX7	V	+170	-25	-20	Y	Y	+170	0	+1±.5	Y
		R	340K	170K	130K	200	200	350K	80K	130K	200
V5	12AX7	V	+170	0	+1±.5	Y	Y	+170	-1	+ .3	Y
		R	340K	80K	115K	200	200	340K	150K	250K	200
V6	12AX7	V	+170	-35	-35	Y	Y	+170	-35	-30	Y
		R	340K	250K	120K	200	200	340K	200K	280K	200
V7	12AX7	V	+100	0	+1±.5	W	W	80	0±.5	+1±.5	W
		R	620K	22M	600K	100	100	1.2M	13K	600K	100
V8	12AU7	V	+170	-45	-35	Y	Y	+170	-.6	0±.5	Y
		R	340K	300K	65K	200	200	340K	4M	18K	200
V9	6AX5	V	--	+170	-180	--	-180	--	+170	+300	--
		R	∞	340K	16K	--	15K	--	340K	∞	--
V10	6AU5	V	+150	+180	+180	--	+300	+150	+180	+300	--
		R	∞	320K	320K	--	∞	∞	340K	∞	--
V11	OG3	V	--	-85	--	--	0	--	--	--	--
		R	--	27K	--	--	0	--	--	--	--
V12	12AX7	V	+150	-1.5±.5	0	Y	Y	+125	-85	-85	Y
		R	∞	1M	0	200	200	500K	280K	25K	200
V13	12AU7	V	+170	-5	0	Y	Y	+170	-5	0	Y
		R	320K	1M	0	200	200	320K	1M	0	200
V14	12AX7	V	+100	0	+1±.5	Y	Y	+170	±.5	+1±.5	Y
		R	500K	0	125K	200	200	340K	1M	125K	200
V15	12AX7	V	+120	0	+1.5±.5	Y	Y	+105	±.5	+1.5±.5	Y
		R	500K	0	580K	200	200	420K	380K	580K	200

Figure 8 - MODEL 350-A(R) TABLE OF VOLTAGE AND RESISTANCE MEASUREMENTS

NOTE: All resistance values in OHMS. K=1,000 M=1,000,000.

W = 2.5 volts ac Y = 3.0 volts ac.

Variations of up to ±20% in all readings can be expected.

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